fourteen stations (this is not a fourth part of the number available), and the Indian longitude stations specified above, fifty-six equations treated by least squares give the following elements of the earth's figure :—

Polar semi-axis ... ... $c = 20854895$ standard feet.
Equatorial semi-axis ... $a = 20926202$,, ,,
$c : a = 292{\cdot}465 : 293{\cdot}465$.

But the evidence of the Indian longitude observations goes to show that the curvature of the surface of India in a direction perpendicular to the meridian is considerably less than that belonging to the spheroid just specified. Possibly this apparent result may be owing to the existence of attractions of the plumb-line seawards at the coast stations. At any rate it suggests the re-investigation of the ellipsoidal form of the earth : and the result of a formidable calculation is that the ellipsoid best representing all the observations has the following semi-axes :—

$a = 20926629$ $b = 20925105$ $c = 20854477$,

and the ellipticities of the two principal meridians

$$\frac{1}{289{\cdot}5} \text{ and } \frac{1}{295{\cdot}8}.$$

The longitude of the greater axis of the equator is 8° 15′ W. of Greenwich—a meridian passing through Ireland and Portugal, and cutting off a portion of the north-west corner of Africa ; in the opposite hemisphere this meridian cuts off the north-eastern corner of Asia and passes through the southern island of New Zealand. The meridian containing the smaller diameter of the equator passes through Ceylon on the one side of the earth and bisects North America on the other. Thus the division of the earth by the meridian plane of the greater axis of the equator corresponds very nearly with the ordinary two-circle representation of the earth, the one showing the Eastern hemisphere the other the Western.

Such is the result of the calculation, and it is a somewhat remarkable result when considered in connection with the actual physical features of the globe, and the distribution of land and sea on its surface. But too much confidence must not be placed in it ; many more measurements would be necessary to establish this figure as a reality ; as yet it is merely indicated by the existing observations, and the amount of the eccentricity of the equator shown above is really very minute.

It is to be observed—returning to the spheroidal figure and comparing this new result with that quoted above from the volume of "Comparisons of Standards"—that the effect of the new work in India has been to increase the radius of the equator by 140 feet, and to diminish the polar radius by 226 feet.

There are several short arcs on the European continent which might have been used in addition to the long arcs, but the influence of these on the result would have been almost imperceptible. The details of the American Coast Survey oblique arc are not yet published.

Notwithstanding the immense additions to geodetical measurements and to the data of the problem of the figure of the earth since Bessel's investigations (1841), it is with a good deal of truth that Karl Maria Friederici says that Bessel's results are still universally adopted by scientific men. And this must be considered a very remarkable instance of the influence of a *name*. Bessel was a splendid mathematician ; his works are characterised by great elegance ; and in this case his fame is a set-off against the increase of data subsequent to his time. But Bessel could only use one-fourth part of the present English arc (and the terrestrial measure of this arc as used by him was some 200 feet in error), and one-third of the present Russian arc. In his time the English, Russian, and Indian arcs amounted in all to less than 27° ; now they exceed 57°. Hence Bessel's figure of the earth cannot be considered anything else than obsolete, however excellent it may have been six-and-thirty years ago.

The operations which are being conducted with so much activity on the European continent and in India must shortly put us in possession of great additions to the data of the problem, especially through the agency of the electric telegraph. As a specimen of the precision now attainable in the determination of longitudes by galvanic signals, we may quote the three results obtained at different times and in different ways for the difference of longitude of Greenwich Observatory and Harvard Observatory (Cambridge, Massachusetts). They are as follows :—

	h.	m.	s.
In 1866, by Anglo-American cables	4	44	31·00
In 1870, by French cables to Duxbury	4	44	30·99
In 1872, by French cable to St. Pierre	4	44	30·96

Doubtless there is a certain amount of good fortune in this, but nevertheless the accordance is highly satisfactory.

AN EXPERIMENTAL INVESTIGATION OF THE STRUCTURE OF FLUID COLUMNS WHICH ARE AFFECTED BY SOUND

WHEN a fluid escapes from a contracted opening, it may form a column, which throughout the greater part of its length has the same sectional shape as the opening. This kind of column may be called prismatic.

It may after leaving the opening form an expansion, this expansion being succeeded by another at an angle (usually a right angle) to it ; and this latter by another, and so on. This kind of column may be called segmental (Fig. 1).

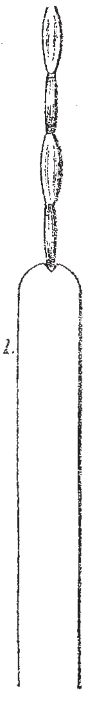

Fig. 1.

An example of the first is obtained when the column proceeds from a true cylinder, truncated at right angles to its axis, and is very difficult to obtain.

A segmental column is easily obtained from the end of a partially closed glass tube.

Segmental columns are sensitive, prismatic columns not sensitive, to sound.

The character of a jet is determined by connecting with a water supply.

The apparatus, Fig. 2, is intended to show the structure of a segmental column. *a*, *b*, *c*, *d* is a piece of cork $2\frac{1}{2}$ in. × 1 in. and 1 inch thick. Pieces of glass tube 2 inches long serve as axes for the corks C C. Each cork is pierced at right angles to its axis to support a jet J. An india-rubber T-piece connects the jets with gas or water supply.

It will be seen that the arrangement permits of the jets being inclined to each other at any angle by the movement of the corks round their axes ; and a lateral adjustment may be obtained by sliding them along their axes.

To make the jets : the middle of a long piece of glass tube is contracted in the blowpipe flame ; when cold a sharp scratch is made in the middle of the contraction, and the tube broken through. Two perfectly equal jets are thus obtained.

Experiment I.—Arrange the jets at an acute angle and connect with a water supply. The segmental column will be obtained. The first (primary) expansion being at right angles to the plane of the jets.

Experiment II.—Keeping the water supply as before, increase the angle of the jets ; the segments will become more marked and the length of the entire column decreased. At a certain angle the primary expansion becomes so great that the cohesion of the

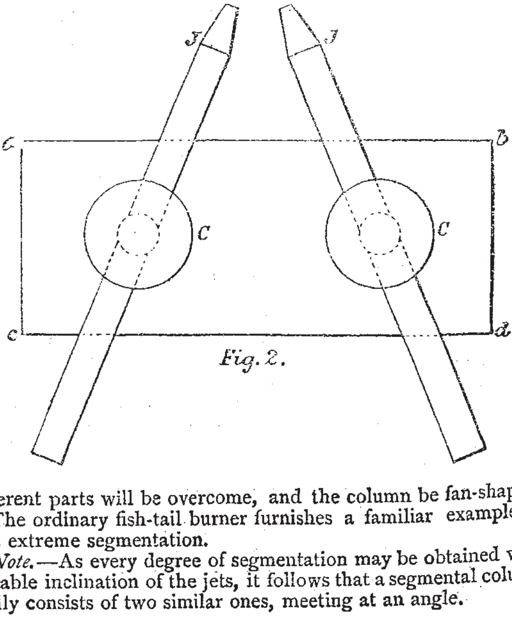

Fig. 2.

different parts will be overcome, and the column be fan-shaped.

The ordinary fish-tail burner furnishes a familiar example of this extreme segmentation.

Note.—As every degree of segmentation may be obtained with suitable inclination of the jets, it follows that a segmental column really consists of two similar ones, meeting at an angle.

Experiment III.—Arrange, as in Experiment I., but connect with a gas supply and ignite. The primary expansion will be obtained but not succeeded by any other. This is readily accounted for. The edges of the expansion, as far as the middle, are receding from each other, and there being no cohesion in gases, they continue to recede, and so the expansion is fan-shaped.

Experiment IV.—Starting with the jets at an angle of about 60° and their ends nearly in contact, lessen the angle and adjust the gas supply, that the flame may take the shape shown in Fig. 3. At a certain point increase of gas will cause the flame to emit a note (usually a very high one), and at the same time commencing somewhere about O[1] there will be an expansion at right-angles to the primary one. A horizontal section of the flame will now have a cruciform contour.

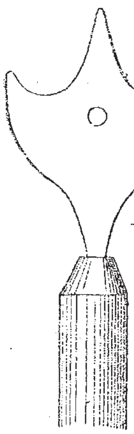

Fig. 3.

Having obtained this musical flame, withdraw the jets through their corks (keeping the same angle throughout). As the distance between them increases the note becomes of lower pitch. With careful attention a very low note may be obtained. At a certain distance the note ceases, but may be restored by additional gas pressure.

Note.—It is evident that the velocity of the gas decreases with its distance from the jet. Hence the greater the velocity the higher the note.

I have shown (NATURE, vol. xv. p. 119) that the velocity of the escaping gas is decreased by ignition, therefore if a certain flame produces a low note the same column unignited will give a higher one. This is found to be the case.

Experiment V.—Having arranged, as in the preceding experiment, reduce the gas supply till the flame ceases to sing. It will now be sensitive to a certain note. Produce this note very near the flame, the flame takes the same shape as when singing (Experiment IV.).

Experiment VI.—Produce a flame tolerably sensitive (Experiment V.). Mount a whistle so that it may revolve round the flame. In two positions, being the ends of a diameter passing through the edges of the flame, the sound will produce no effect.

Note.—It will be seen that the sonorous impulses strike the flame in such a manner that the two columns are thrown into the same phase of vibration. The maximum effect is produced at points at right-angles to the minima. The waves reaching the nearer column first will throw it into a phase differing from the distant one.

Experiment VII.—Select jets of such a size that a flame may be obtained as large as one's hand. At a pressure just below that at which it sings it will be highly resonant.[2]

A sound produced in its vicinity will cause it to resound. When the exciting note has ceased, the sound of the flame will gradually subside; at the same time giving forth higher and higher harmonics of the note.

The sounds, however, are very feeble, and can only be heard at a very short distance. A convenient arrangement for amplifying the sound, is to place the stoppered end of a large gas jar in contact with the ear, and direct the open mouth towards the flame. With a correct adjustment any note within a very wide range will excite the flame, which may emit the same, or some harmonic of it. By whistling an air with the mouth, a rather pleasing accompaniment is heard, and the extreme gravity of some of the flame-notes is certainly remarkable. I have not succeeded in augmenting the notes so as to make this a lecture experiment.

Fig. 4 consists of a cork or other suitable material about 6 in. long, and 1 in. wide and thick. The axis of a jet A is directed to just pass clear of the top of a jet B. A is supported in a cork so that it may approach or recede from B. The end of A is contracted till it will give a flame about $1\frac{1}{2}$ inch long, under the full pressure of the gas mains ($\frac{6}{10}$ in. water).

[1] This corresponds with the intersection of axes of the jets.

[2] A large gas supply is indispensable, and very careful adjustment is required to obtain the most favourable result. A pressure of $1\frac{1}{2}$ inches of water is sufficient.

When tested with water it should show very slight segmentation.

Experiment VIII.—Produce at B the smallest possible flame, and direct the full flame from A, so that the point just passes over the top of B. Extinguish A without turning off the gas. The issuing gas will form a bluish cone beyond B, the space between A and B remaining unignited.

A may now be withdrawn from B till the cone becomes unsteady. If the column has very slight segmentation the distance may be five or six inches. With most jets, however, the limit will be about three or four inches.

This column is exceedingly sensitive. The faintest sound to which it responds will cause the ignited cone to recede towards A.

The greater length, and therefore the greater velocity of the unignited column will be at once noticed (*vide* Experiment IV.)

Experiment IX.—Arrange as Experiment VIII., and remove A just so far, that the cone does not strike back to it. Now very softly produce the responding note. The column recedes and becomes ignited through the whole of its length.

Experiment X.—Replace A by a rather more segmental jet, and obtain the cone. It will be seen that when the cone recedes, it is divided at the extremity more or less perfectly, into two parts.

Experiment XI.—Replace the jet B by a disc of spongy platinum[1] about the size of a halfpenny.

The unignited column causes an annular patch of the platinum to become red hot. When the column is excited the annulus is divided into two spots. The same column, if previously ignited, will not be affected by the same sound.

This forms another proof of the excitability of the unignited column.

In Fig. 5 two equal jets inclined to each other at an acute angle, are fixed in a cork which freely slides in a tube 5 in. × $\frac{5}{8}$ in.

Experiment XII.—Using the apparatus (Fig. 5), slide the cork near the top of the tube and ignite the gas. Slowly lower the cork till a point is reached at which the flame is sensitive. Observe that the base of the quiescent flame in contact with the tube forms a sinuous line, consisting of two depressions and two crests at right angles to each other; and further, that the crests correspond in position with the edges of the primary expansion, and the depressions consequently with the sides.

Note.—When the flame is excited their relative positions are reversed.

Experiment XIII.—Use a low gas pressure (one or two tenths) with Fig. 5, and slide the cork down the tube till the base of the flame becomes unsteady. At a certain point a

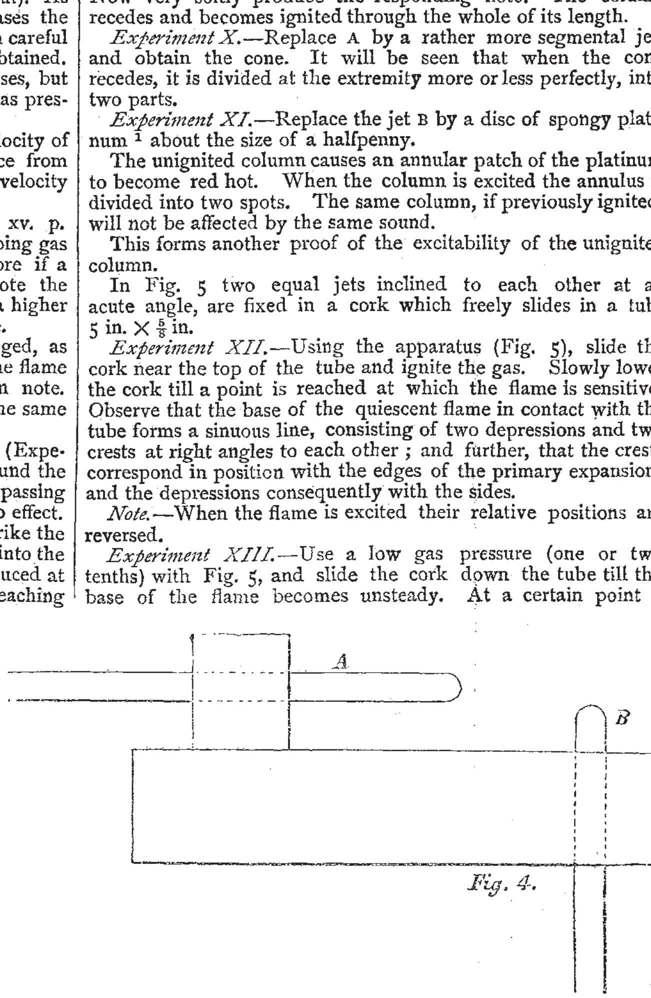

Fig. 4.

noise will cause the flame to move from side to side *in the same plane as the jets.* Increase of pressure accelerates the movement.

Instruments for the production of sensitive flames may be divided into two classes :—

1. Those in which the whole of the gaseous column is ignited.
2. Those in which the column is only partially ignited.

[1] A good substitute for the spongy platinum is obtained by pounding some fine asbestos till quite smooth, moistening with a tolerably strong solution of platinum tetrachloride, moulding the mass into the required shape in a piece of paper, and igniting. The paper burns off and leaves a porous fragile mass. This is alternately soaked in the platinum solution and ignited three or four times, when it becomes tolerably durable.

CLASS I.

Ignited Columns.

a. The apparatus described by Prof. Barratt, *Phil. Mag.*, April, 1867.

b. Described in this paper, Fig. 2, *et seq.*[1]

CLASS II.

Partially-ignited Columns.

a. Described in NATURE, vol. v. p. 30.

b. Described in a former communication, December 7, 1876.

c. Described in this paper, Fig. 4, *et seq.*

I. *a* consists of a glass tube with a tapering jet. A V-shaped cut made across the end of the jet renders it more sensitive. If such a jet be connected to a water-supply it will be found to be segmental. If it has the V-shaped groove this will be more marked. The primary expansion lies in the groove in most cases. The only use of the latter is to render the column more certainly segmental.

Fig. 5.

The column being segmental, consists (Experiment II., note) of two streams, one on each side the groove meeting at a very acute angle.

When there is no groove little irregularities in the orifice determine the segmentation of the column. The friction of the long, narrow jet and the ignition of the gas at the orifice retard the outflow, and to obtain a sufficient velocity the gas must issue under a considerable pressure[2] (one or two feet).

When excited it shortens and expands at *right angles to its primary expansion.*

I. *b* has been described (Fig. 2, *et seq.*). The jets meeting at a considerable angle, the column is flattened. It responds in the same manner as the preceding, but the primary expansion being very short, the responding expansion is usually the longer one.

II. *a* consists of a tapering jet placed a small distance below a piece of fine wire gauze. The gas is ignited above the gauze. It is very sensitive, but the intersection of the column by the gauze prevents the flame from taking any well-marked form when responding.

II. *b* is practically the same as the foregoing. The column being surrounded for a part of its length by the closed tube, remains unignited in this part.

The excited flame divides distinctly into two parts, which are in a plane at *right angles* to the primary expansion.

This division appears to arise from the tendency of the excited flame to form a flat expansion, and the edges being reflected from the inside of the tube, because the same jet when used without the tube and under a high pressure, does not divide, but produces a fan-shaped expansion.

II. *c* is shown in Fig. 4. The flame from B keeps the column beyond it heated to the ignition point. It is of interest as showing the use of the gauze in II. *a* and the tube in II. *c*, and further, that the value of the tube in the latter does not depend upon its resonance.

In Experiment IV. it is shown that a sensitive-flame, when emitting a note, sends out an expansion at right angles to the primary one, the same behaviour being observed when the flame is excited by an external sound. It therefore follows that if these actions are conversely related to each other, that a responding flame should emit a note. This will always be found to be the case; but the sound being usually very feeble, may escape observation unless some means be adopted to concentrate it (*vide* Experiment VII.).

The expansion occurs just above the intersection of the axes of the jets. Call these *a* and *b*. The two columns strive for a mastery of direction. *a* overcomes *b* and sends a tongue of flame through the primary expansion, but the partial stoppage of *b* causes an increase of pressure by which in turn it overcomes *a*, and sends a tongue of flame through the other side of the primary expansion, and so on. These movements succeeding each other with very great rapidity in a high note, and gas being highly elastic it is impossible to recognise them separately. Experiment XIII. shows how the impulses may be obtained so slowly as to be individually perceived.

When the gas pressure is so low that the column is quiescent, a sound is necessary to start the operation; and further the sound must so strike the component columns as to give one of them an advantage (*vide* Experiment VI.).

I have only referred to water columns as far as was necessary to illustrate the behaviour of gaseous ones. They should form a subject for separate consideration.

Summary.

1. A fluid column if sensitive to sound consists of two columns meeting at an angle (Experiment II. *note*).
2. The resultant of the two columns is an expansion (Experiments II. and III.).
3. A column so constituted will under favourable conditions emit a note (Experiment IV.).
4. If excited by an external sound, it takes the same form as when it spontaneously emits the sound (Experiment V.).
5. A column excited as in 3 and 4 sends out an expansion at an angle (usually a right angle) to the primary expansion.
6. The component column of a sensitive column must be at such unequal distances from the sounding body that they are not thrown into the same phase of vibration (Experiment VI. and *note*).
7. A gaseous column increases in sensitiveness with the pressure, *i.e.*, the velocity.
8. A gaseous column is lessened in velocity by ignition at its origin (Experiment VIII.). Hence—
9. A gaseous column when ignited is less sensitive than when unignited (Experiment IV.).

R. H. RIDOUT

[1] Lecomte has previously shown that the fish-tail burner is sensitive.

[2] By making a V-groove across the end of a partially-closed tube, this kind of jet becomes tolerably sensitive at a pressure of three inches

THE AURORA OBSERVATIONS OF THE AUSTRO-HUNGARIAN ARCTIC EXPEDITION, 1872-74, *BY CARL WEYPRECHT*

THE Austro-Hungarian Arctic Expedition of 1872–74 was in many respects an unfortunate one. Not only was the first winter occupied with an unintermitted struggle with the ice, which from hour to hour threatened to crush the ship, and rendered it imperative that everything should be in constant readiness for her sudden abandonment, but in the second year this had actually to take place, and, on account of their bulk, valuable records of scientific observation were unavoidably left behind, and among these was the carefully-kept journal of northern-light observations.

Under such discouraging conditions the mass of valuable observations which Lieut. Weyprecht has succeeded in collecting from the meteorological and magnetic journals and other sources, are interesting not only on account of their many positive contributions to our knowledge, but as an example of wonderful scientific industry and devotion.

Spite of the perpetual changes of the aurora, Weyprecht considers that its appearances may be classified under five distinct forms, viz., the *arch*, the *ribbon* or *streamer*, the *rays*, *crown*, and *haze* (*Bogen*, *Band*, *Fäden*, *Krone*, and *Dunst*). His description of these forms differs in several particulars from those common in lower latitudes, so that we may be excused for noticing them at some small length.

Arches (*Bögen*, *arcs*) are of regular form; the highest point closely coincides with the magnetic meridian and the ends cut the horizon at points equi-distant from it. They usually move either northward or southward, rising from the edge of a low dark segment near the horizon, or again vanishing into it. The rim of light which edges this dark segment is probably only a low and distant bow, or possibly the combined effect of all the remoter arches which are melted into each other by distance and perspective. This is the more likely since a bow is never observed to sink wholly below the horizon, but fades into this distant rim, and, conversely, from it, arches frequently arise and separate themselves as they get higher. Not unfrequently the arches sink back to the point from whence they arose; at other times they gradually fade away as they near the zenith, or after they have passed it. Very intense displays never take the form of regular arches.